

- I. *The Description and Use of an Arithmetical Machine invented by Christian-Ludovicus Gersten, F. R. S. Professor of Mathematicks in the University of Giessen. Inscribed to Sir Hans Sloane, Bart. President of the Royal Society. [See TAB. Fig. 1, 2, 3, 4, 5.]*

S I R,

B EING at present on the Point of returning Home, I think myself obliged before my Departure, to return my humble Thanks to that Learned Body the *Royal Society*, over which you preside, for the Honour they have lately done me, in chusing me a Member; and to make a grateful Acknowledgment to you in particular, for the many Favours and Civilities, which, according to that amiable Character of Benevolence to all Strangers in general, you have been pleased to bestow on me.

It is now a Duty incumbent on me to communicate to the *Royal Society* from time to time any thing new and curious, which may fall in my way: Therefore I now lay before them a Draught and Description of an *Arithmetical Machine*, which I invented about twelve or thirteen Years ago.

Sir *Samuel Morland* was, for ought I know, the first who undertook to perform Arithmetical Operations by Wheel-work. To this end he invented two different Machines, one for *Addition* and *Subtraction*, the other for *Multiplication*, which he published in *London*, in the Year 1673, in *small*

Twelves. He gives no more than the outward Figure of the Machines, and shews the Method of working them. But as by this every one, who has any Skill in Mechanicks, will be able to guess, how the inward Parts ought to be contrived ; so it cannot be denied, that these are two different Machines, independent of one another ; that the last, which is for *Multiplication*, is nothing else but an Application of the *Neipperian* Bones on flat moveable Disks ; consequently that his Invention alone is not fit to perform justly all Arithmetical Operations.

After him the celebrated Baron *de Leibnitz*, the Marchese *Poleni*, and Mr. *Leupold* took this Undertaking in hand, and attempted to perform it after different Methods.

The first published his Scheme in the Year 1709, in the *Miscellanea Berolinensia*, but then he gave only the outward Figure of the Machine. Signor *Poleni* communicated his, but explaining at the same time its inward Construction, in his *Miscellanea* of the same Year, 1709. Mr. *Leupold's* Machine, together with those of Mr. *de Leibnitz* and Signor *Poleni*, were inserted in his *Theatrum Arithmetico-Geometricum*, published at *Leipzig* in 1727, after the Author's Death, yet imperfect, as it is owned in the Book itself.

Besides these, I learned from several *French* Journals, that *Charles Pascal* invented one, which however I never had the sight of.*

* The Description of this Machine is since printed by *M. Gallon* in his Collection of Machines and Inventions approved by the *Academy of Sciences at Paris* (published in *French at Paris*, 1735. in *Quarto*, in Six Tomes) in *Tom. IV. p. 137* ; and likewise another by *M. Lespine*, *Tom. IV. p. 131* ; and three more by *M. Hellerin de Boississandeau*, *Tom. V. p. 103, 117, & 121.*

I took the Hint of mine from that of Mr. *de Leibnitz*, which put me upon thinking how the inward Structure might be contrived : But as it was not possible for me to hit upon the original Ideas of that Great Man, an exact Enquiry into the Nature of Arithmetical Operations furnished me at last with others, which I expressed in a rough Model of Wood, and shewed to some Patrons and Friends, who encouraged me to have another made of Brass : But the want of an Artificer, able enough to execute my Ideas, made me delay it till the Year 1725 ; when having spare Time, and finding an Inclination to divert myself with Mechanical Operations, I set about it, and finished the whole Work, fitted to a Reckoning not exceeding seven Places. And in *December* of the same Year, I had the Honour to lay this Machine before my Sovereign, the present Landgrave of *Hessen Darmstadt*, and the Hereditary Prince his Son, to whom I demonstrated the Mechanism of the whole Invention.

I own that the gracious Reception it met with from both their Highnesses, as well as the express Recommendation of Mr. *de Wieger*, one of the Prince's Privy-Council, would have been powerful Inducements for me to have publish'd at that time an Account of my Machine ; but I was checked by the Uncertainty I was under, whether possibly Mr. *Leibnitz's* Machine had not been brought to its Perfection ; in which case there is no doubt but the Operation of his Machine, if it would really perform what is promised in the Description, would have been easier than mine, and consequently preferable to it, provided its Structure did not prove

too intricate, nor that the working of it took up too much time.

But at present, being certain that none of Mr. *Leibnitz's* Invention has yet appeared in such a State of Perfection, as to have answer'd the Effect propos'd, and that these of mine differ from all those mentioned above, fancying at the same time, that Persons who understand Mechanicks, will find it plain, practicable, and exact, in regard to its various Effects, I make no Scruple to present to the *Royal Society* this Invention, the Product of my younger Years indeed, but now with the several Amendments I have since added to it, as a Mark of the Respect and Veneration I have for this illustrious Body.

The Particulars of it are as follows :

There are as many Sets of Wheels and moveable Rulers as there are Places in the Numbers to be calculated. *Fig. 1.* shews three of them, by which one may easily conceive the rest. A A shews the first System or the Figures of Unites, according to its inward Structure. B B and C C shews the second and third System, *viz.* of Tens and Hundreds, according to their outward Form. We shall first consider A A ; where $\alpha\alpha\alpha$ is a flat Bottom of a Brass Plate, which may be skrewed on either upon a particular Iron Frame, or only upon a strong Piece of Walnut-Tree, doubled with the Grain cross'd. In this System are two moveable Rules *gggg*, and *kkk*, the first of which I call the Operator, the second the Determinator. There are besides two Wheel-Works, the upper one is for *Addition* and *Subtraction*, the lower one serves for *Multiplication* and

and *Division*. The upper one is provided first with *a*, an oblique Ratchet-Wheel of 10 Teeth, of what Diameter you please, on which, however, depends the Length and Breadth of the System itself. This Wheel has a Stop *r*, with a depressing Spring *t*; Under the Wheel *a* is a smaller Wheel *b* of the same Shape: Both *a* and *b* are rivetted together, and fixed on a common Axis. Under the Wheel *b* lies a third *f*, which is a common Tooth-Wheel of 20 or more Teeth, according as one pleases: It is larger than *b*, and smaller than *a*, turns about the same Axis with the other two above it, and upon it is fixed a Stop *c*, with the Spring *d*, which catches the oblique Teeth of the Wheel *b*. Immediately under this Wheel lies the upper Part of the Operator, which may be best made of Iron or Steel. The Wheels may all be of Brass, except the upper one. The Operator is of the same Thickness all over, and in its upper Part are fixed as many round Steel Pins as there are Teeth in the Wheel *f*, which are to catch the Teeth of this Wheel, and move it backwards and forwards. The Height of those Pins ought exactly to answer the Thickness of the Wheel *f*. The Axis of the Wheels *a* and *b* is kept perpendicularly by the Bridge *ee*, which is skrewed to the Bottom, as appears by the Figure. The Operator *gggg* moves on the Side, above, and in the Middle in two Brass Grooves *iii* and *qq*; about D it jets out, on which Projection a Piece of Iron *h* must be well fastened, having a strong Pin, on which the Handle *z* fits, as you see in the System B B. The Side D itself slides in another Groove *ss*, and in its inner Corner joins to it the Determinator *kkk*, of
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the same Thickness with the Operator, the Shape of which is sufficiently expressed in the Figure. This slides also up and down, on the one Side in the Groove *ss*, and *v* on the other Side, where it is smallest, in a small Piece of Brass *u*, and where it is broadest, above in the Operator itself, which is either hollowed out into another Groove, or filed off obliquely. The sliding Part of the Determinator ought afterwards also to be fitted to it. Its chief Part is the Lock *u*, standing perpendicular on its broad Part. I have drawn it separately in *Fig. 4. BB*, in which the sliding Stop *c*, which is pressed down by its Spring *d*, but raised by the Tricker *aa*. That Tricker has a Pin *b*, on which is skrewed on the small Handle *ll* (*Fig. 1. in the Systems BB and CC.*) In the Brass Bottom *AA* (or *αα Fig. 1.*) you must file out 10 Ratchet-Teeth or Kerfs, purposely for the Stop of this Lock, or, which is better, you may insert into the Brass Bottom a small Piece of Iron filed out according to this Figure. The Partition and Length of these Ratchet-Teeth in the Bottom must fit exactly with the Circumference of the Wheel *f*, (*Fig. 1. System AA,*) with this Direction, that if the Lock is kept by the uppermost Tooth in the Bottom, the Operator cannot be moved at all; but when by pressing down the Tricker *aa*, (*Fig. 4*) the Determinator is shoved down, and is stopp'd by the second or third Tooth in the Bottom, the Operator being also drawn down as far as the Determinator permits, makes the Stop *c* (*Fig. 1. Syst. AA*) slide over 1 or 2 Teeth of the second Wheel *b*; consequently the same Stop *c*, must slide over 9 Teeth, when the Lock of the Determinator will

will stand before the 10th Tooth in the Bottom, and the Operator is pulled down so far. If you have a mind to apply these Ratchet-Teeth on the Outside of the Plate $\odot \odot$, that covers the Whole, you may fit the Lock to it accordingly : But in this Case the Covering-Plate must be well fastened.

For *Multiplication* and *Division*, there is properly in each System but one Wheel, likewise divided into 10 Ratchet-Teeth, on which is rivetted the round Plate l , on which are engraved the Numbers or Figures : These Wheels have no occasion for any Bridge, but may turn about a strong Pin of Steel, folder'd to the Bottom. The Ratchet-Wheel mm rests on one Side upon the Determinator, and upon a Piece of Brass of the same Thickness, to which are fastened the Stop n , and the Spring p . Upon the Operator is another Stop o , with its Spring ; which Stop has a small Arm at o , which is checked by a small Studd, to hinder the Spring's pressing the Stop lower down than it ought : By which Contrivance it is so order'd, that after the Operator is slid down so far as it can go, in being slid up again, the Stop o will turn but one Tooth of the Wheel mm . The round Plate l has in its Middle a small hollow Axis, on which are turned first two Shoulders, and then a Skrew : This Skrew in the System A A is an ordinary one, winding from the left to the right.

But as each System ought to have Communication with the preceding one, though not with that which follows ; to this end a projecting Tooth of Communication made of Steel q is rivetted to the upper Plane of the uppermost Wheel a . This Tooth

must be placed exactly on the Point of a Tooth of the Wheel, and by its Revolution catches and turns every time but one Tooth of the uppermost Wheel of the preceding System, sliding over the following one (if there be any) without touching it. For this reason the Planes of the Brass Bottoms in all the Systems ought to incline a little. This will best appear from the Vertical Section, *Fig. 2.* (cut in *Fig. 1.* in the Direction from *b* to *f*) in which *a* is the Brass-Bottom, *HH* the Wood-Bottom, *g* the Operator, *i* the Groove, *f* the third common Tooth-Wheel, *b* the second Wheel, *a* the first or uppermost Ratchet-Wheel, *e* the Bridge, \odot the Covering-Plate, and *z* the Tooth of Communication. I have represented all these Pieces of one Thickness; but every Artift will easily know where to add or take off.

Fig. 5. shews the Plan and true Disposition of the Teeth in the several uppermost Wheels; that is to say, The Parallel Lines *AB* and *CD* ought always to cut the Brass Bottoms (which are like one another in Length and Breadth) length-wise into two equal Parts: Then the perpendicular Interfection *EF* will determine the Centers *a* and *b*, of the two Wheels *H* and *G*. The Stop *r* ought every time to hold its Wheel in such a manner, that the Points of two Teeth coincide with the Line *AB* or *CD*. The Obliquity of the Teeth is the same in both, with this difference however, that in *G*, which is a Wheel of the System *AA*, (*Fig. 1.*) they are cut in from the left to the right, but in *H* (a Wheel of the System *BB*) from right to the left. I need not take notice, that for making the Work more durable,

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the Teeth are not to be cut out into quite sharp Points, but blunted a little, as in the Wheel H. The Nicety of the whole Machine chiefly consists in placing the Center *a* and *b*, or (which amounts to the same thing) after having chosen the Breadth of the Brass-Bottoms, in determining the Diameter of the uppermost Wheel : For if that should prove so large, as that the two Wheels H and G should very near touch one another, the Tooth of Communication will be short, its Operation will be of a small Force, and the Wheels themselves will require a very great Exactness, lest by turning about the Wheel H, and the Tooth of Communication standing in the Position as it is represented in *Fig. 5*, a Tooth of the Wheel H may touch it, and stop the Motion. Whereas, on the other hand, supposing the Centers at the same Distance, and the Diameters of both Wheels less, the Tooth of Communication will be longer : then such an Exactness is not requir'd in the Wheel, yet more Force is necessary for making the Tooth of Communication lay hold the better. Furthermore, it will be well for you to make the undermost common Tooth-Wheel as large as you can.

From the Construction of this first System, with which the 3d, 5th, 7th, &c. entirely agree, one may easily imagine the 2d, 4th, 6th, 8th, &c. for every thing there also is the same, except only, that it is inverted ; so that what in the first stands on the Right-hand, is on the Left in the second.

The Plate for *Multiplication* has on its hollow Axis, as it is said before, two Shoulders, the lowermost of which is very small, the Sum of its Height, the Thickness of the Plate of the Wheel *mm*, and of

the Operator must amount to as much as answers to the Height of the Bridge *ee*. On both Ends of the Brads-Bottoms, the two Piece of Brads *cc*, of the same Height, are rivetted on. This being done, at last the Covering-Plates *oo* is prepared and skrewed on the Piece of Brads *cc*. If the Machine be made pretty large, the Covering-Plate must be skrewed fast, not only to the Bridge *ee*, but also not far from the Wheel of Multiplication. It must be provided not only with round Holes, through which are to go the Axis of each uppermost Wheel *a*, and the hollow Axis of the Plate *l*; but it must also have a long Slit, in which the Operator and Determinator may be moved up and down, and last of all a small Window over the Plate of *Multiplication*, through which the Figure or Number engraved on the Plate may appear distinctly. To the projecting Skrew *l*, of the Plate *l*, is fitted an Handle *ff*, joined to an Index in the Shape of a Scythe. The Skrew in the System *AA* is a common Skrew, consequently the Roundness of the Scythe must turn from the left to the right; but in the System *BB*, where it ought to be inverted, like all the other Parts, the Scythe must turn from the right to the left, as in the Figure. The Use of this is to shew which Way the Wheels are to be turned; and the Skrews are to prevent the Machine's being hurt by unskilful Hands.

On the Side of the Determinator, *viz.* on that Piece which cannot be pressed down, is also skrewed a small Index, which may be directed to such Numbers or Figures as is required. These Figures are to be engraved in the Covering-Plate, according

to the Figure, and their Distance depends on the Ratchet-Teeth *ee* (*Fig. 4.*) in the Brass-Bottom.

On the Axis of each uppermost Wheel *a* (which Axis must be made square as far as it projects over the Covering-Plate) is fixed a thin round Silver-Plate *xx* (in the Systems BB and CC) or *ad* in *Fig. 3.* yet so that it may not rub against the Covering-Plate. It has a hollow Axis *bc* (*Fig. 3.*) on which is a right or left Skrew, according to the System it belongs to, and a small Shoulder *c*. To the Skrew is skewed the Handle *fs* (System BB and CC, *Fig. 1.*) which is vertically flat on the Extremity, in order to turn by it the Plate and the Wheels. The Plate (as appears by the Figure) is divided by 3 concentrick Circles into two Rings, in the outmost of which are engraved the Numbers for *Addition*, in the inmost those for *Substraction*. I will hereafter call this Plate only the *Silver-Plate*, the first Ring the *Addition-Ring*, the second the *Substraction-Ring*: Moreover two Indexes *w* and *y* are skewed to the Covering-Plate; *w* shews the Numbers of the outmost or *Addition-Ring*, and *y* those of the *Substraction-Ring*. They have Hinges, that they may be lifted up, and the *Silver-Plate* taken out or put in again: Their Curvature serves for a Direction, which way the Plates ought to be turned. A skilful Artificer will be able to give them a neater and handsomer Shape, than here in the Draught, where I would not cover the Numbers.

All this being done, there remains now the Figures or Numbers to be engraved, in the manner following: Place each uppermost Wheel *a* (System AA) so, that the Tooth of Communication be ready to

catch (as in G, *Fig. 5*) which may be easily felt. Observe in the Silver-Plate, where the Index *w* points, and there engrave the Number or Figure 9, lower down in the *Subtraction-Ring*, where the Index *y* points, engrave the Cypher 0. After this divide both Rings into 10 equal Parts, one of which is already designed for 9 in the *Addition*, and another for 0 in the *Subtraction-Ring*; then observe which way the Wheel turns, if from the right to the left, as in System BB; then you must from the engraved Number 9 in the *Addition-Ring*, towards the right engrave 0 next, then 1, 2, 3, 4, &c. and in the *Subtraction-Ring* towards the right also, from the already engraved 0, first engrave 9, then 8, 7, 6, &c. *ordine inverso*. But if the Wheel turns from the left to the right, as in the Systems AA and CC, you engrave the Numbers or Figures in the same Order, but from the right to the left (See in *Fig. 1.* the Systems BB and CC.)

In the *Multiplication-Wheels mm* you must conduct the Index *ff* exactly to the Window, as it is drawn in the System BB; mark the Place on the round *Multiplication-Plate* under the Window, and engrave upon it the Cypher or 0: Then make, by two concentrick Circles, a Ring upon this Plate, and divide this Ring into ten equal Parts, and after the 0 (already engraved) engrave on the Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, in the same Order as it was done in the *Addition-Ring* of the Silver-Plate of the same System. Last of all, if you think fit, you may skrew on thin Ivory Plates, to note upon them the Numbers which are to be calculated, particularly a long small one on that Side of the Slit of the Determinator, where there are no Numbers, and also two shorter

shorter broader ones, one under the Window of *Multiplication*, the other above the Silver-Plate. All this together composes a Machine, by the help of which you may perform all the four Arithmetical Rules or Operations. The Way of working it, is as follows :

1. *As to Addition* : For instance, if you are to add 32 and 59 ; because the hindmost System A A in the Figure, which ought to represent the Place of Unites, is not cover'd, let us take the System B B for the Place of the Unites, and the System C C for the Place of the Tens ; turn the Silver-Plates *xx* in these two Systems, that the Indexes *ww* point to the two Numbers 5 and 9 ; then make the Determinators *ll*, *ll*, point also to 3 and 2 : next take one of the two Operators, *ex. gr.* in B B, and pull it down as far as you can, and move it upwards again. This done, the Number 1 of the Silver-Plate in B B will come by this means under the Index *w*, and the Number 6 of the Silver-Plate in the System C C under its Index at the same time, which is 61, the Sum, 59 and 2. After this move the Operator of the System C C also up and down, when instead of 6, 9 will come under the Index ; consequently you have 91 under the Indexes *ww*, which is the Sum requir'd of 59 and 32 added together. The Reason of it is plain ; for by pulling down the Operator of the System B B so far, the Stop *c* of the lowermost or common Tooth-Wheel *f* (*vid.* Syst. A A) will slide over two Teeth of the Ratchet-middlemost Wheel *b* ; and by moving the Operator up again, the same Stop *c* will turn the two Ratchet-Wheels *a* and *b* together, and cause the Stop *r* of the

the great or uppermost Wheel *a* to slide also over two Teeth ; at the same time the Tooth of Communication *g* will move forward one Tooth of the uppermost Ratchet-Wheel in the System CC ; consequently on the Silver-Plate in BB, instead of 9 the Number 1, and in System CC, instead of 5 the Number 6 must appear under their Indexes *ww* ; and so for the same reason, having pulled up and down the Operator of the System CC, the Number 6 pointed to by the Index must be at last changed into 9.

II. *Subtraction.* Suppose 40 the Sum, from which you are to subtract 24 : Here you must put your Sum 40 in the *Subtraction-Rings* ; that is to say, turn the Cypher *o* in the System BB, and the Number 4 in the System CC, under the Indexes *yy*, as the Figure shews : Set the Determinators at 24, as in *Addition* ; move also the Operators only once up and down, the Remainder 16 will appear under the Indexes *yy*. As for the Reason of this Operation, when you consider, that the Numbers in the *Subtraction-Rings* are engraved *inverso ordine*, as it is said before, you will find that it is the same as in *Addition*.

III. *Multiplication.* For instance ; if you are to multiply 43 by 3, bring the *o* in all your *Addition-Rings* to the Indexes, as also in all your *Multiplication-Plates* in the Windows. Write down (which is more particularly necessary if the Numbers are larger than here) the Multiplicand 43 upon the Ivory-Plates near the two Determinators in the two Systems BB and CC : But the Multiplier 3, you may write only on the Ivory-Plate under the
Window

Window of the System BB. Set the Determinators at 43 ; then move your Operators successively as often up and down, till there appears in both Windows the Number 3 ; then you will see on your *Addition-Rings* under the Indexes, the Product 129.

It is easy to understand, that as the *Multiplication* is nothing else than a repeated *Addition*, the Machine does also perform its Operation by a repeated *Addition* only : For the Number 3, which appears in the Window of the System BB, shews how many times you have added the Number 3, pointed by the Determinator to itself, which when done 3 times, is 9. And so the same Number 3, which appears in the Window of the System CC, after your Operation, shews how many times you have added the Number 4. to itself. I need not to make you observe, that besides the two Systems BB and CC, there must be supposed another, not express'd in the Figure, which will shew the Number 1 of the Product 129.

IV. *Division*. If you are, for instance, to divide 40 by 3, set your Dividend 40 in the *Subtraction-Rings* under the Indexes *yy*, in the System BB and CC ; turn the Indexes *ff*, *ff*, near the Windows to make 0 appear ; write your Divisor near the Determinator of the System CC, and set the Determinator at 3 ; pull the Operator up and down, then you will have 1 under the Index *y*, and 1 likewise in the Window. By this you see, that you cannot work further in this System CC, because you cannot subtract 3 from 1 : You must therefore go on, to the other Figure of the Dividend, *viz.* 0, and in the System BB set the Determinator again at 3.

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This being done, the first pulling of the Operator up and down will produce 1 in the Window, and 7 in the *Subtraction-Ring* under the Index, and the Number 1 which remained before in the System CC will be changed into 0. Now as 7 is more than 3, you must work on accordingly ; having done it twice more, you will find that there remains under the Index y but 1, (which is the Numerator of your Fraction) and below in the two Windows the Quotient 13. When you consider that *Division* is nothing else but a repeated *Subtraction*, you will also easily understand the reason of this Operation.

Those that understand the matter ever so little, may now easily conceive how they are to proceed with this Machine in larger *Examples* : However, for greater Clearness, I will explain it by two *Examples*.

Supposing there are six Systems, *a, b, c, d, e, f*;

Let all the Numbers pointed to by the Indexes *ww* be in AB; those which are to be pointed to by the Determinators, in CD; and those which are seen in the Windows, in EF. First of all,

	<i>f</i>	<i>e</i>	<i>d</i>	<i>c</i>	<i>b</i>	<i>a</i>	
A	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	B
C			3	5	6	3	D
E	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	$\frac{\circ}{-}$	F
					5	8	

you must turn all your *Addition-Rings* of the *Silver-Plates* and your *Multiplication-Plates* to 0 ; viz. that under all the Indexes *ww*, and in the Windows nothing may appear but 0. Write the Number 3563 near the Determinator, in the Systems *a, b, c, d*, and direct them accordingly : The other Number 58, you must write down likewise, but under the Windows in System *a* and *b*, as you see in this

Scheme.

Scheme. Move the several Operators, which are moveable, successively as often up and down, till 8 appears below in the Windows, and you will have under the Indexes above 28504, the Product of 3563×8 . And so the Numbers of the Machine will appear thus.

A	\overline{f} ○ —	\overline{e} 2 —	\overline{d} 8 —	\overline{c} 5 —	\overline{b} ○ —	\overline{a} 4 —	B
C			3	5	6	3	D
E	\overline{f} ○ —	\overline{e} ○ —	\overline{d} 8 —	\overline{c} 8 —	\overline{b} 8 —	\overline{a} 8 —	F
					5	8	

to 0, except in the System *a*. See the *Scheme* following.

A	\overline{f} ○ —	\overline{e} 2 —	\overline{d} 8 —	\overline{c} 5 —	\overline{b} ○ —	\overline{a} 4 —	B
C		3	5	6	3		D
E	\overline{f} ○ —	\overline{e} ○ —	\overline{d} ○ —	\overline{c} ○ —	\overline{b} ○ —	\overline{a} 8 —	F
					5	8	

Next advance your Multiplicand 3563, from the Right to the Left ; that is to say, place the Determinator in the System *b* at 3, in *c* at 6, in *d* at 5, in *e* at 3, and reduce every Number in the Windows

Then pull all the Operators again successively in *b, c, d*, and *e*, up and down, till 5 appears in the Windows below, and you will find at last under the Indexes 206654, the Product of 3563×58 .

A	\overline{f} 2 —	\overline{e} ○ —	\overline{d} 6 —	\overline{c} 6 —	\overline{b} 5 —	\overline{a} 4 —	B
C		3	5	6	3		D
E	\overline{f} — —	\overline{e} 5 —	\overline{d} 5 —	\overline{c} 5 —	\overline{b} 5 —	\overline{a} 8 —	F
					5	8	

N

But

But if you are to divide again 206654 by 3563, you must place the Dividend above in the *Subtraction-Rings* under the Indexes. In the Windows below, every Figure must be 0, likewise as in the *Multiplication*; and write the Divisor under the Dividend, according to *Vulgar Arithmetick*, and as in the *Figure* here annexed.

	f	e	d	c	b	a	
A	$\frac{2}{-}$	$\frac{0}{-}$	$\frac{6}{-}$	$\frac{6}{-}$	$\frac{5}{-}$	$\frac{4}{-}$	B
C		3	5	6	3		D
E	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	F

If you direct the Determinators in *e, d, c, b*, to their Numbers, and subtract this Divisor by pulling up and down the Operators as often as you can, you will have in the Windows in *e, d, c, b*, every where 5; but on the *Silver-Plates* there will remain 28504. Now advancing your Divisor from the Left to the Right, bringing to the Windows in *d, c, b*, all the Cyphers 0, and operating as before, there will at last appear on the *Silver-Plates* nothing at all, but below in the Windows 5888. See the *Figure* following:

	f	e	d	c	b	a	
A	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	$\frac{0}{-}$	B
C			3	5	6	5	D
E	$\frac{5}{-}$	$\frac{8}{-}$	$\frac{8}{-}$	$\frac{8}{-}$	$\frac{8}{-}$		F

And here you have only this to observe, that in such Cases, you cut off all the hindermost Figures or Numbers in E F, except that which stands under the first Figure of the Divisor; what remains is your Quotient.

As for what remains, if it be objected that this Machine cannot be fitted for so many and long Numbers,

Numbers, as one would please, because the Multiplication of so many Systems would require too great a Force for one Operator to move so many Wheels, kept by Springs, supposing the case that all the Teeth of Communication should duly catch ; I own that this Objection is but too well grounded : However, I cannot help observing at the same time, that this Defect can hardly be avoided, in any Arithmetical Machine, for performing all those Operations of itself, without the help of the Mind : For there must certainly be a particular System for each Place of Figures, which is to communicate with the next ; consequently, as the Systems encrease in Number, the Force must encrease also which is requir'd for moving them all. Besides, it ought to be consider'd, of what Size such a Machine ought to be, which might serve for common Use. I think few Calculations could be required, for which 14 or 16 Systems might not suffice. That which I made was of 7 Systems, as I have already mention'd. The Disposition of it was neither so well contrived as I have explained it here, nor were its several Parts so well wrought, as a good Artificer, who makes Profession of such Work, might have performed it ; yet those 7 Systems were very easily put in Motion ; and if in a Machine for 14 Figures made by a skilful Hand, it could not be so easily practicable, this Defect, I believe, might be easily remedied, by applying the other Hand in the fifth or sixth System to the Handle *β*, in order to ease and assist the Operator.

I am your humble Servant,

C. L. GERSTEN.

